

Application No. 09/683,658
Reply to Office Action of April 4, 2005

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Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claims 1-103 (cancelled)

Claim 104. (New) An apparatus, comprising:

a capsule having an interior surface defining a volume, and the capsule is configured to receive a material and a fluid in the capsule volume, the capsule both is sealable, and is operable to maintain a seal while the capsule is subject to a predetermined temperature and to a predetermined pressure, and the fluid is operable to become supercritical at least at the predetermined temperature and the predetermined pressure;

a restraint having an interior surface defining a chamber, and the chamber is configured to receive the capsule, and the restraint is responsive to resist a pressure exerted by the capsule against the restraint interior surface and to maintain the chamber at a substantially constant volume; and

an energy source operable to supply thermal energy to the capsule, wherein the fluid is responsive to the thermal energy both to become supercritical at the predetermined temperature and at the substantially constant volume in the chamber, and to increase the pressure in the volume to at least the predetermined pressure.

Claim 105. (New) The apparatus as defined in claim 104, wherein the restraint is operable to counterbalance pressure in the capsule generated by the fluid in response to thermal energy, and the restraint is immobile relative to the capsule while counterbalancing the capsule pressure.

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Claim 106. (New) The apparatus as defined in claim 104, further comprising a heating system that includes the energy source and a temperature sensor, wherein the temperature sensor is disposed proximate to the capsule and is operable to sense a temperature of the capsule.

Claim 107. (New) The apparatus as defined in claim 106, further comprising a control system communicating with the heating system and the temperature sensor, wherein the control system is operable to provide a closed loop temperature control in response to a signal generated by the temperature sensor.

Claim 108. (New) The apparatus of claim 107, wherein the heating system comprises a heating element that is electrically resistant and is configured as one or more of a foil, a tube, a ribbon, a bar, or a wire.

Claim 109. (New) The apparatus of claim 108, wherein the heating element comprises one or more of niobium, titanium, tantalum, nickel, chromium, zirconium, molybdenum, tungsten, rhenium, hafnium, or platinum.

Claim 110. (New) The apparatus of claim 108, wherein the heating element comprises stainless steel or silicon carbide.

Claim 111. (New) The apparatus of claim 107, wherein the control system is operable to control the heating system to differentially heat a first portion of the capsule volume to a first temperature and a second portion of the capsule volume to a second temperature.

Claim 112. (New) The apparatus of claim 104, further comprising a clamp in contact with the restraint, wherein the clamp is operable to reduce a pressure load on at

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least a portion of the restraint, and the pressure load can cause a longitudinal stress or an axial stress or both a longitudinal and an axial stress on the restrain portion.

Claim 113. (New) The apparatus of claim 112, further comprising a gasket disposed between the clamp and the restraint portion.

Claim 114. (New) The apparatus of claim 113, wherein the gasket comprises an electrically insulating gasket that comprises one or more of carbon-based material, salt, oxide, nitride, or silicate.

Claim 115. (New) The apparatus of claim 114, wherein the carbon-based material comprises one or more of natural rubber, synthetic rubber, polyester film, polyimide, fluorocarbon polymer, tetrafluoroethylene fluorocarbons, fluorinated ethylene-propylene, or a glued paper composite.

Claim 116. (New) The apparatus of claim 114, wherein the gasket comprises one or more of talc, olivine, magnesium oxide, calcium carbonate, calcium oxide, strontium oxide, barium oxide, merylinite clay, bentonite clay, sodium silicate, or textilite.

Claim 117. (New) The apparatus of claim 114, wherein the gasket comprises hexagonal boron nitride.

Claim 118. (New) The apparatus of claim 114, wherein the gasket comprises an electrically conductive element at least partially disposed within the gasket, and the electrically conductive element comprises one or more of molybdenum, tungsten, tantalum, niobium, nickel, or cobalt, or an alloy of two or more thereof.

Claim 119. (New) The apparatus of claim 114, wherein the gasket comprises an

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electrically conductive element at least partially disposed within the gasket, and the electrically conductive element comprises one or more of copper, brass, graphite, iron, or stainless steel.

Claim 120. (New) The apparatus of claim 104, further comprising a seal operable to seal the capsule.

Claim 121. (New) The apparatus of claim 120, wherein the seal comprises a deformable ring operable to form a seal between the restraint and a clamp supporting the restraint.

Claim 122. (New) The apparatus as defined in claim 104, further comprising a pressure transmission medium disposed within the restraint chamber and surrounding at least a portion of the capsule, wherein the pressure transmission medium is operable to maintain an outer pressure on the capsule.

Claim 123. (New) The apparatus as defined in claim 122, wherein the pressure transmission medium is thermally stable up to about 1000 degrees Celsius and has an internal friction of less than about 0.2.

Claim 124. (New) The apparatus as defined in claim 122, wherein the pressure transmission medium is a solid up to about 1300 degrees Celsius.

Claim 125. (New) The apparatus as defined in claim 122, wherein the pressure transmission medium comprises one or more of talc, pyrophyllite, molybdenum disulfide, graphite, hexagonal boron nitride, silver chloride, calcium fluoride, strontium fluoride, calcium carbonate, magnesium oxide, zirconium oxide, merylinite clay, bentonite clay, or sodium silicate.

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Claim 126. (New) The apparatus as defined in claim 122, wherein the pressure transmission medium comprises one or more of sodium chloride, sodium bromide, or sodium fluoride.

Claim 127. (New) The apparatus as defined in claim 104, wherein the restraint comprises a die, a punch, and a press, and the die is one of a straight-wall die, an angled-wall die, or a concave-wall die.

Claim 128. (New) The apparatus as defined in claim 104, wherein the restraint comprises one or both of cemented tungsten carbide or hardened steel.

Claim 129. (New) The apparatus as defined in claim 127, wherein the restraint further comprises a compression ring, and the die is receivable within the compression ring.

Claim 130. (New) The apparatus as defined in claim 104, wherein the restraint is operable to transmit pressure to the capsule such that the transmitted pressure to the capsule is measurable as a pressure response of less than about 0.2.

Claim 131. (New) The apparatus as defined in claim 104, wherein the restraint is operable to transmit pressure to the capsule such that the transmitted pressure to the capsule is measurable as a pressure response of less than about 0.05.

Claim 132. (New) The apparatus as defined in claim 104, wherein the restraint comprises a multi-anvil press.

Claim 133. (New) The apparatus as defined in claim 132, wherein the restraint

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further comprises a plurality of support plates, and each support plate is disposed between a respective anvil and a pressure transmission medium surrounding at least a portion of the capsule.

Claim 134. (New) The apparatus as defined in claim 104, wherein the restraint comprises a first end flange and a second end flange spaced from the first end flange, a die disposed between the first and second end flanges, and a fastener joining the first end flange to the second end flange.

Claim 135. (New) The apparatus as defined in claim 134, wherein each end flange comprises a structural support configured to reinforce the corresponding end flange.

Claim 136. (New) The apparatus as defined in claim 104, wherein the capsule comprises a malleable metal selected from the group consisting of steel, copper, silver, gold, and platinum, and wherein the capsule, when sealed, is impermeable to hydrogen.

Claim 137. (New) The apparatus as defined in claim 104, wherein the capsule comprises a liner that lines the capsule interior surface, and the liner comprises one or more of gold, platinum, rhodium, palladium, silver, iridium, ruthenium, silica,

Claim 138. (New) The apparatus as defined in claim 137, wherein the liner has a thickness in a range of from about 1 micrometer to about 5 millimeters.

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Claim 139. (New) The apparatus as defined in claim 104, further comprising a press in pressure communication with a pressure transmission medium, and the pressure transmission medium is in pressure communication with the capsule, and the press is operable to apply only a pre-load pressure to the pressure transmission medium prior to operation of the energy source.

Claim 140. (New) The apparatus as defined in claim 139, wherein the press is further operable to remain immobile in response to pressure exerted by the capsule to the pressure transmission medium.

Claim 141. (New) The apparatus as defined in claim 104, wherein the material comprises a metal and a nitrogen-containing compound.

Claim 142. (New) The apparatus as defined in claim 141, wherein the metal comprises aluminum.

Claim 143. (New) The apparatus as defined in claim 104, wherein the fluid comprises ammonia.

Claim 144. (New) The apparatus as defined in claim 104, wherein the fluid is sufficiently responsive to thermal energy to pressurize the capsule to an internal pressure in a range of greater than about 5 kbar, and the capsule and the restraint are cooperatively configured to maintain the seal at the internal pressure and at the corresponding temperature.

Claim 145. (New) The apparatus as defined in claim 104, wherein the fluid is sufficiently responsive to thermal energy to pressurize the capsule to an internal pressure in a range of greater than about 60 kbar, and the capsule and the restraint are

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cooperatively configured to maintain the seal at the internal pressure and at the corresponding temperature.

Claim 146. (New) An apparatus, comprising:

a capsule having an interior surface defining a volume, the capsule being configured to receive an amount of metal material and an amount of ammonia in the capsule volume, the capsule both is sealable to maintain an internal pressure, and is operable to maintain a seal while the capsule is subject to a predetermined temperature and to a pressure in a range of up to about 80 kBar;

a restraint having an interior surface defining a chamber that is configured to receive the capsule, and the restraint is responsive to resist a pressure exerted by the capsule against the restraint interior surface and to maintain the chamber at a constant volume, and wherein the restraint is operable to provide no active pressure load to the capsule, or a pre-load pressure only to the capsule; and

an energy source operable to supply thermal energy to the capsule, such that the ammonia responds to the thermal energy at the constant volume in the chamber to increase the pressure in the chamber and to become supercritical ammonia, wherein the supercritical ammonia reacts with the metal material to form a metal nitride composition.